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#22 Appeal Brief, SDavis 11/14/03

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventors:	Rajiv Jain et al.		
Assignee:	QuickLogic Corporation		
Title:	Method of Programming an Antifuse		
Serial No.:	09/887,834	Filing Date:	June 22, 2001
Examiner:	Terry Cunningham	Group Art Unit:	2816
Docket No.:	QKL9351 US	Confirmation No.:	7855

Santa Clara, California
October 24, 2003

Mail Stop Appeal Brief - Patents
Commissioner For Patents
P.O. Box 1450
Alexandria, VA 22313-1450

APPELLANT'S BRIEF

Dear Sir:

This Brief is filed on behalf of the Applicant(s) in the above-referenced case pursuant to the Notice of Appeal filed on August 28, 2003.

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(1) Real Party in Interest

The real party in interest is the assignee, QuickLogic Corporation.

(2) Related Appeals and Interferences

There are no related appeals or interferences.

(3) Status of Claims

Claims 1-25 are pending, of which Claims 1-3, 5-18, and 21-25 were rejected and Claims 4, 19, and 20 were allowed. The rejection of Claims 1-3, 5-18, and 21-25 is appealed.

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(4) Status of Amendments

There have been no amendments to the claims subsequent to the final rejection. Fig. 5 and accompanying text were amended subsequent to the final rejection. The Examiner indicated in the Advisory Action of August 19, 2003, that the objection to the Drawings has been overcome.

(5) Summary of Invention

The present invention is related to a method of programming antifuses. Antifuses are semiconductor devices that include a programmable material (112, Fig. 1) that is disposed between two conductive elements (102 and 114, Fig. 1). The programmable material is substantially non-conductive when unprogrammed and substantially conductive when programmed.

The inventive method of programming an antifuse includes applying multiple programming pulses of opposite polarity to the antifuse. Page 2, lines 25-26. One embodiment of the invention includes passing a first pulse (202, Fig. 2), sometimes referred to as a prepulse, through the antifuse material (112, Fig. 1) so as to drive material from said first conductive element into said material as a conductive filament (113, Fig. 3). Page 5, lines 18-30. The first pulse is a current limited pulse (202, Fig. 2; and block 302, Fig. 6). Page 5, lines 23-24. The first pulse is followed by passing a second pulse (204, Fig. 2) in the opposite direction through the antifuse material so as to drive material from said second conductive element into said material thereby increasing the cross sectional area of said conductive filament (113a, Fig. 4) and reducing the resistance of the antifuse. Page 6, lines 3-20. The current in the first pulse (202, Fig. 2) is lower in magnitude than the current of the second pulse (204, Fig. 2; and block 304, Fig. 6) and the first pulse (202, Fig. 2) is passed through the material prior to any other pulse (Fig. 2, Fig. 6). Page, 5, lines 12-17 and page 8, line 28-page 9, line 8.

In another embodiment, a prepulse (202, Fig. 2; and block 302, Fig. 6), having a current of a first magnitude is applied to the programmable material prior to applying a programming pulse (204, Fig. 2, block 304, Fig. 6) having current of a second magnitude.

Page 5, lines 18-20, page 6, line 3-4, and page 8, line 28-page 9, line 8. The current of the prepulse is less than the current of the programming pulse, and the prepulse is applied before the programming pulse. Page 6, lines 3-9, and page 8, line 28-page 9, line 8.

In another embodiment, a first voltage and first current (202, Fig. 2) are applied to the programmable material followed by the application of a second voltage and second current (204, Fig. 2) to the programmable material. The first current drives a conductive filament (113, Fig. 3) with a first cross sectional area through the programmable material (112, Fig. 3) and the second current increases the size of the conductive filament (113a, Fig. 4) to a second, greater, cross sectional area. Page 6, lines 17-20. The first voltage and second voltage have the same magnitude but opposite polarity (page 5, lines 14-15, lines 20-21, page 6, lines 4-5), and the second current has a greater magnitude and opposite polarity than the first current (page 6, lines 7-8). The first current has insufficient magnitude to produce a conductive filament with the second cross sectional area. Page 5, line 28-30.

(6) Issues

Whether Claims 1-3, 5-18, and 21-25 are unpatentable under 35 U.S.C. §102(b) as being anticipated by Chan (5,243,226)?

(7) Grouping of Claims

Claims 1, 3, 5-10, 12-18, 22, and 24-25 stand and fall together and Claims 2, 11, 21, and 23 stand and fall together.

(8) Argument

Claims 1-3, 5-18, and 21-25 were rejected under 35 U.S.C. §102(b) as being anticipated by Chan (5,243,226) ("Chan").

CLAIMS 1, 3, 5-10, 12-18, 22, and 24-25

Claim 1 recites "passing a first pulse through said material so as to drive material from said first conductive element into said material as a conductive filament, said first

pulse is a current limited pulse", "passing a second pulse through said material in the opposite direction of said current limited pulse", and "wherein the current in said current limited pulse is lower in magnitude than the current in said second pulse, and wherein said current limited pulse is passed through said material prior to any other pulse".

The Examiner has taken the position that Chan discloses passing a first pulse 210.1 with current I1 and passing a second pulse 210.2 with current I2 through the antifuse. The Examiner referred to Col. 3-4 of Chan stating that it "express[es] that the provision of I2 being less than I1 is merely as [sic] an example." Final Office Action dated June 5, 2003, page 2. The Examiner further stated that "[i]t is clear from Cols. 3-4 of Chan (as well as other portions thereof) that the disclosed circuit is not limited to I2 being less than I1. It is further clear that one skilled in the art will get similar results wherein I2 is greater than I1, however, the reduction of resistance of the [sic] will not be as consistent." Final Office Action dated June 5, 2003, page 3.

Appellant respectfully disagrees and submits that contrary to the Examiner's statement, Chan is not "clear" regarding these points. Nowhere in Chan is there a discussion of using a first current I1 that is less than the second current I2 to program an antifuse. The express teachings of Chan, in fact, focus on using a second current I2 that is less than the first current I1. Appellant respectfully submits that the Examiner's statement that the provision of I2 being less than I1 is "merely an example" is misleading. The provision of I2 being less than I1 is discussed throughout Chan and is not "merely an example": it is the only example.

The Examiner has not provided reference to an express disclosure in Chan that I2 may be greater than I1, nor does Appellant's attorney believe such an express disclosure exists.

Chan, however, does repeatedly state that the current I1 of pulse 210.1 is greater than the current I2 of the second pulse 210.2. Col. 3, lines 65-66; col. 4, lines 8-14; Table 1; Table 2; col. 4, line 67-col. 5, line3; and see col. 6, lines 40-45; col. 13, lines 2-3; col. 13, lines 15-20. By way of example, in columns 3 and 4, Chan discusses experiments where I1 was greater in magnitude than I2. See, Table 1 and Table 2 and

accompanying text. Chan further notes that in other experiments, I1 was between 11.6 mA and 45 mA and I2 between -9mA and -35mA. Chan states "In each experiment, current I2 was 20-25% lower in magnitude than current I1." Col. 5, line 1-3.

In the Office Action, dated June 5, the Examiner chose to ignore the express teaching of Chan, as cited by Appellant, stating "none of these portions are seen to contradict the above rejection."

The Examiner provided his reasoning as follows:

> As an example, Col. 4, lines 8-16, states that "The second pulse 201.2 reduces the antifuse resistance more consistently if current I2 is lower in magnitude than current I1". It is more than clear from this disclosure that if I2 is higher than I1, the antifuse resistance will be less consistent. From this and the rest of Col. 3-4, it is understood, by clear implication, that I2 can in fact be higher than I1, although the result will be less consistent.

Office Action, dated June 5, page 3.

It is black letter law that "[a] claim is anticipated only if each and every element as set forth in the claim is found, either expressly or inherently described, in a single prior art reference." Verdegaal Bros. v. Union Oil Co. of California, 814 F.2d 628, 631, 2 USPQ2d 1051, 1053 (Fed. Cir. 1987) (emphasis added). As discussed above, Chan does not expressly describe each and every element set forth in the claims. Thus, the Examiner is relying on inherency.

As stated in In re Robertson, 169 F.3d 743, 49 USPQ2d 1949 (Fed. Cir. 1999), "to establish inherency, the extrinsic evidence 'must make clear that the missing descriptive matter is necessarily present in the thing described in the reference, and that it would be so recognized by persons of ordinary skill.'" (Quoting Continental Can Co. v. Monsanto Co., 948 F.2d 1264, 1268, 20 U.S.P.Q.2d 1746, 1749 (Fed. Cir. 1991)). In re Roberston, further states that "[i]nherency, however, may not be established by probabilities or possibilities. The mere fact that a certain thing may result from a given set of circumstances is not sufficient." Id. (emphasis added).

The Examiner does not provide any evidence that Chan inherently discloses or even suggests that I2 is greater than I1. The Examiner's rejection is based merely on an "implication" of the possibility that I2 can be greater than I1. "Inherency, however may not be established by probabilities or possibilities." In re Robertson, 169 F.3d 743, 49 USPQ2d 1949 (Fed. Cir. 1999).

Moreover, Appellant disagrees with the Examiner's underlying premise that Chan implies I2 can be greater than I1. Chan's statement that "the antifuse resistance [is reduced] more consistently if current I2 is lower in magnitude than current I1" is a comparison to having the same magnitude currents I1 and I2, not, as the Examiner assumes, in comparison to having I2 greater than I1.

Appellant's interpretation is consistent with other statements in Chan. For example, Chan states that "[r]educing |I1| runs against the general rule that a greater current through the antifuse provides lower resistance." Col. 4, lines 14-16. According to this general rule, if multiple currents are used to program an antifuse, the magnitude of the currents I1 and I2 should be the same, i.e., the maximum permissible current. Thus, Chan's statement that "the antifuse resistance [is reduced] more consistently if current I2 is lower in magnitude than current I1" does not imply that I2 may be greater than I1, but that according to the general rule, one would expect the best results if both I2 and I1 were the maximum permissible current, i.e., I2 is equal to I1.

Appellant asserts that contrary to the Examiner's position, it is not clear why one of ordinary skill in the art would abandon the express disclosure of Chan (that the second current I2 is less than the first current I1), if doing so would result in less consistent antifuse resistance. Further, even if one of ordinary skill in the art were to abandon the express disclosure of Chan, i.e., that the second current I2 is less than the first current I1, then the general rule, as stated in Chan, would lead one to believe that the magnitude of I2 and I1 should be equal, i.e., both should be as large as possible, not that I2 can be greater than I1.

Accordingly, Chan does not expressly or inherently disclose all the elements of Claim 1. Claim 1 is not anticipated by Chan. Thus, the group consisting of Claims 1, 3, 5-10, 12-18, 22, and 24-25 which stand and fall together are all allowable.

Moreover, while the Examiner did not reject the claims as obvious, Appellant asserts that an obviousness rejection would likewise be improper. Chan does not provide a suggestion or motivation to apply to the antifuse material a second current I2 that is less than the first current I1. Further, Chan teaches away from such a modification, by stating that the "general rule [is] that a greater current through the antifuse provides lower resistance", which leads to the conclusion that the currents I1 and I2 should be the same, i.e., the maximum permissible current.

<u>CLAIMS 2, 11, 21, and 23</u>

The group of Claims 2, 11, 21, and 23, which stand and fall together, are similar to the group of Claims 1, 3, 5-10, 12-18, 22, and 24-25 and are patentable for at least the same reasons discussed above. Claims 2, 11, 21, and 23, however, include an additional element that the magnitude of the voltage of the first pulse (the prepulse) is approximately the same as the magnitude of the voltage of the second pulse (the programming pulse). Thus, Claims 2, 11, 21, and 23 are independently patentable and stand and fall together.

By way of example, independent Claim 21 recites "applying a first voltage across said material and a first current through said material " "applying a second voltage across said material and a second current through said material, <u>said second voltage having the same magnitude and opposite polarity as said first voltage</u>" and "wherein said first current is applied through said material prior to any current which has sufficient magnitude to produce a conductive filament with said second cross sectional area".

Chan does not teach or suggest that the first pulse 210.1 and the second pulse 210.2 have the same voltages. In fact, Chan explicitly teaches that the pulse 210.1 has a voltage of 13V while the second pulse has a voltage of 9V. Col. 6, lines 40-45; Col. 13,

lines 2-3; Col. 13, lines 15-16. To Appellant's attorney's knowledge, there is no disclosure in Chan to the contrary. Further, the Examiner has not addressed this additional element despite having been raised by Appellant in the Response to Office Action, dated April 30, 2003.

Thus, the group of Claims 2, 11, 21, and 23, which stand and fall together are independently allowable over Chan.

For the above reasons, Appellant respectfully requests reversal of the rejection of Claims 1-3, 5-18, and 21-25. Should there by any questions concerning this Appeal Brief, Appellant's attorney may be reached at (408) 982-8202.

Via Express Mail Label No. ER 158 144 301 US

Respectfully submitted,

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Appendix

The following claims are involved in this appeal:

1. A method of programming an antifuse, said antifuse comprising a material that is substantially non-conductive when said antifuse is unprogrammed, said material being disposed between and in electrical contact with a first conductive element and a second conductive element, said method comprising:

passing a first pulse through said material so as to drive material from said first conductive element into said material as a conductive filament, said first pulse is a current limited pulse; and

passing a second pulse through said material in the opposite direction of said current limited pulse so as to drive material from said second conductive element into said material thereby increasing the cross sectional area of said conductive filament and reducing the resistance of said antifuse;

wherein the current in said current limited pulse is lower in magnitude than the current in said second pulse, and wherein said current limited pulse is passed through said material prior to any other pulse.

2. The method of Claim 1, wherein said current limited pulse and said second pulse have approximately the same voltage with opposite polarity.

3. The method of Claim 1, wherein said current in said current limited pulse is 20 to 33 percent lower in magnitude than said current in said second pulse.

5. The method of Claim 1,

wherein passing said current limited pulse through said material comprises applying a first voltage to said first conductive element and applying a second voltage to said second conductive element, said second voltage being greater in magnitude than said first voltage, and limiting the current to a desired magnitude; and

wherein passing said second pulse through said material comprises applying said second voltage to said first conductive element and applying said first voltage to said second conductive element.

6. The method of Claim 1, wherein said material comprises amorphous silicon and said conductive filament comprises silicide.

7. The method of Claim 1, further comprising passing a plurality of current limited pulses through said material prior to passing said second pulse through said material.

8. The method of Claim 7, wherein passing said plurality of current limited pulses through said material comprises passing at least two current limited pulses through said material, said at least two current limited pulses being opposite in polarity.

9. A method of programming an antifuse, said antifuse comprising a material that is substantially non-conductive when said antifuse is unprogrammed, said material

being disposed between and in electrical contact with a first conductive element and a second conductive element, said method comprising:

applying a prepulse to said material, said prepulse having a current of a first magnitude that drives material from said first conductive element into said material as a conductive filament; and

applying a programming pulse to said material, said programming pulse having a current of a second magnitude that drives material from said second conductive element into said material adding to said conductive filament;

wherein said current of said first magnitude is lower than said current of said second magnitude, and wherein said prepulse is applied prior to applying any programming pulses.

10. The method of Claim 9, wherein said current of said second magnitude is 20 to 33 percent greater in magnitude than said current of said first magnitude.

11. The method of Claim 9,

wherein said prepulse has a first voltage applied to said first conductive element and a second voltage applied to said second conductive element; and

wherein said first programming pulse has said second voltage applied to said first conductive element and said first voltage applied to said second conductive element.

12. The method of Claim 9, wherein said current of said programming pulse is applied in the opposite direction of said current of said prepulse.

13. The method of Claim 12, further comprising applying a second programming pulse to said material, said second programming pulse having a current of a third magnitude, said current of said second programming pulse being applied in the same direction of said current of said prepulse.

14. The method of Claim 13, wherein said third magnitude is not greater than said second magnitude.

15. The method of Claim 13, wherein said third magnitude is greater than said second magnitude.

16. The method of Claim 13, further comprising repeatedly applying said first programming pulse and said second programming pulse a predetermined number of times.

17. The method of Claim 13, further comprising repeatedly applying said first programming pulse and said second programming pulse until the resistance of said antifuse is below a predetermined value.

18. The method of Claim 9, further comprising applying at least one additional prepulse to said material prior to applying said programming pulse.

21. A method of programming an antifuse, said antifuse comprising a material that is substantially non-conductive when said antifuse is unprogrammed, said method comprising:

applying a first voltage across said material and a first current through said material, said first current driving a conductive filament with a first cross sectional area through said material; and

applying a second voltage across said material and a second current through said material, said second voltage having the same magnitude and opposite polarity as said first voltage, said second current having a greater magnitude and opposite polarity as said first current, said second current increasing the size of said conductive filament to a second cross sectional area, said second cross sectional area being greater than said first cross sectional area;

wherein said first current having insufficient magnitude to produce a conductive filament with said second cross sectional area, and wherein said first current is applied through said material prior to any current which has sufficient magnitude to produce a conductive filament with said second cross sectional area.

22. A method of programming an antifuse, said antifuse comprising a material that is substantially non-conductive when said antifuse is unprogrammed, said method comprising:

applying at least one prepulse to said material, said prepulse including a first current to drive a conductive filament through said material, said first current having insufficient magnitude to produce said conductive filament with a desired resistance; and

applying at least one programming pulse to said material after the application of said at least one prepulse, said programming pulse including a second current having a greater magnitude than said first current to increase the cross sectional area of said conductive filament and to decrease the resistance of said conductive filament to a desired resistance,

wherein said prepulse is applied prior to the application of any programming pulses.

23. The method of Claim 22, wherein said prepulse and said programming pulse have the same magnitude voltages with opposite polarities.

24. The method of Claim 22, further comprising applying at least one additional prepulse to said material wherein said at least one prepulse and said at least one additional prepulse define a plurality of prepulses.

25. The method of Claim 24, wherein said plurality of prepulses have currents of approximately the same magnitudes with each prepulse having a current of an opposite polarity from an immediately preceding prepulse.